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Review

Role of phosphate fertilizers in heavy metal uptake and detoxification of toxic metals

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HIGHLIGHTS

- Phosphorus fertilizers in soil.
- Phosphate rock as a major source for phosphate fertilizer.
- Uptake of phosphate and heavy metals.
- Rhizosphere, root exudates and elemental uptake.
- Phosphate starvation and signaling in plants.

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ABSTRACT

As a nonrenewable resource, phosphorus (P) is the second most important macronutrient for plant growth and nutrition. Demand of phosphorus application in the agricultural production is increasing fast throughout the globe. The bioavailability of phosphorus is distinctively low due to its slow diffusion and high fixation in soils which make phosphorus a key limiting factor for crop production. Applications of phosphorus-based fertilizers improve the soil fertility and agriculture yield but at the same time concerns over a number of factors that lead to environmental damage need to be addressed properly. Phosphate rock mining leads to reallocation and exposure of several heavy metals and radionuclides in crop fields and water bodies throughout the world. Proper management of phosphorus along with its fertilizers is required that may help the maximum utilization by plants and minimum run-off and wastage. Phosphorus solubilizing bacteria along with the root rhizosphere of plant integrated with root morphological and physiological adaptive strategies need to be explored further for utilization of this extremely valuable nonrenewable resource judiciously. The main objective of this review is to assess the role of phosphorus in fertilizers, their uptake along with other elements and signaling during P starvation.

Contents

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1. Introduction

Phosphorus (P), a non-metallic multivalent chemical element in group 15 of the periodic table (pnictogen), is one of the most important macro-nutrient for living systems. It is an essential element for plant growth and for a couple of physiological functions that are concerned with energy transformations. Globally, the main user of phosphorus is agriculture, accounting for about 90% of the total world demand. Input of phosphorus is vital for food production as all plants need an ample supply of it. Being an essential constituent of cells, P is involved in a number of cellular processes, including photosynthesis, respiration, energy storage and transfer, cell division, and cell enlargement. Sufficient amount of phosphorus is required for the promotion of early root formation, development and growth, improvement of crop quality and seed formation. Plants used to uptake phosphate from soils, which then enters into the food chain, and returns to soils as decayed organic residues. Most of the phosphates become incorporated as organic compounds by living systems and when they are released into the environment again, become a part of soil organic matter, which is then mineralized by soil microorganisms. P may exist in diverse forms in soils. However, in general, three different P pools (solution, active and fixed) control the P-cycle in nature. Plants used to take up phosphate from solution. The solution P pool is comprised of P in the orthophosphate form and small amounts of organic P. This pool contains a very small fraction of the total P in soil, which needs to be replenished in due course of time as growing plants deplete the soluble source faster. However, P from the active P pool is the main source of available P for plants, which is released to the soil solution simply to the water adjoining soil constituents. Mostly attached or adsorbed to small particles in the soil along with elements like Ca, Al, the inorganic active P pool easily mineralizes by the biogenic activities in soil. However, source of the phosphate is an important issue as different heavy metals

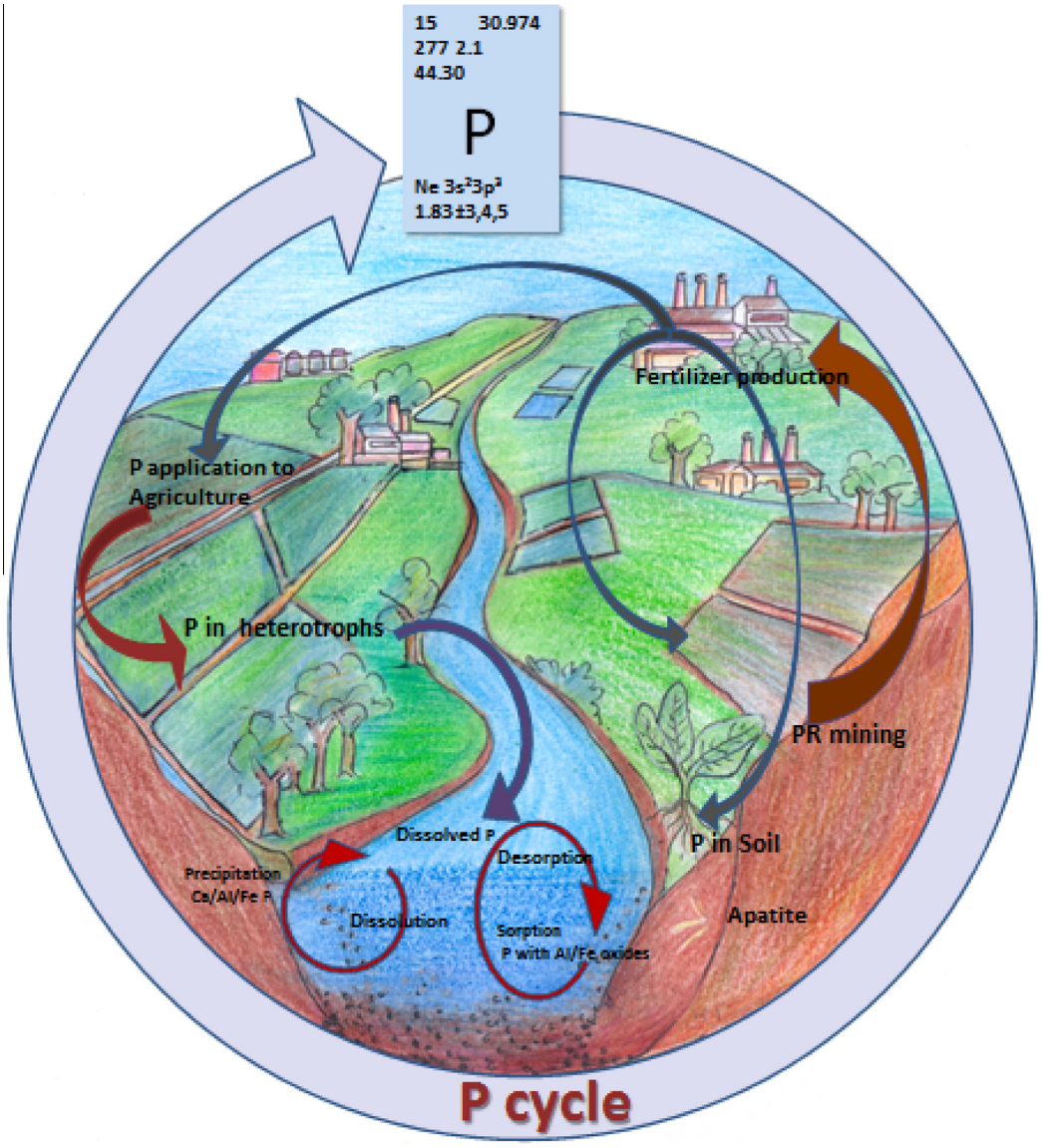

Fig. 1. Schematic representation of the biogeochemical cycle of phosphorus through lithosphere, hydrosphere, and biosphere which is an essential component for plant growth. Phosphate usually comes from rock phosphate deposits and minerals (apatite). Natural dissolution of phosphate rock is restricted by the rate of release and small amount of this released phosphorus is taken by biota. To meet the demand of phosphorus, phosphate rock mining is a common practice to produce the fertilizer that enters the crop and food chain of the ecosystems.

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